Heliophysics Technology And Instrument Development For Science

Development of a Sodium Lidar for Spaceborne Missions

Completed Technology Project (2017 - 2020)

Project Introduction

Layers of neutral metal atoms, such as Iron (Fe), Magnesium (Mg), Calcium (Ca), Potassium (K) and Sodium (Na), which peak between 85 and 95 km and are ~20 km in width, are produced by the daily ablation of billions of Interplanetary Dust Particles (IDPs). As these metallic species are ionized during ablation, by sunlight's ultraviolet photons, or by charge exchange with existing atmospheric ions, meteoroids affect the structure, chemistry, dynamics, and energetics of the Mesosphere and Lower Thermosphere (MLT). The strong optical signals that some of these metal layers produce, in particular the Na layer, makes them an optimal tracer of atmospheric dynamics and circulation and enabling the measurement of quantities, such as composition, temperature and winds, that are critical to address several compelling scientific questions related to the Earth's Upper Atmosphere and the Geospace Environment. In recent years, remote-sensing satellites have obtained the first global characterization of the basic structure of the MLT region in terms of large-scale temperature and wind climatologies, resulting in a much richer picture of the structure and variability of the mesosphere. Although these measurements have shown the high temporal variability of both the zonal mean state as well as large scale organized perturbations, such as planetary waves and atmospheric tides, they failed at providing information required for the fundamental characterization of how the basic state is established and maintained. Thus there is a pressing need in the Ionosphere-Thermosphere-Mesosphere (ITM) community to be able to perform high-resolution measurements that can be used to characterize the small-scale variability in the MLT on a global basis. Such measurements must include highly resolved, in space and time, global temperatures profiles, which will add to the understanding of key indicators of radiative cooling in the mesosphere. We propose to develop and demonstrate an integrated ground-based operational sodium lidar science instrument using key "space-flight-precursor" components. In this way, a ground-based Na lidar will demonstrate the spaceflight instrument viability in a cost-efficient approach and will serve as the core for the future planning of a Heliophysics space mission. Since Ground-based and airborne Na lidar measurements have been made for decades, we know that this remote sensing technique is ideal to obtain the critical measurements mentioned above. A fluorescence lidar measures temperature directly (without measuring air density), and does not rely on any assumptions about hydrostatic equilibrium. Our proposed approach is compelling because the key technologies (i.e. the laser transmitter, optical filter and the photon counting detectors) that are required will be leveraged from instruments with spaceflight heritage. The photon counting detector technology is identical to the technology used on ICESat/GLAS; the etalon filter is the same as being used on ATLAS and the laser is a modified version of the GLAS, MLA, LOLA (all Nd:YAG) and ATLAS (Nd:YVO4) Neodymium (Nd) solid state laser technology. The utilization of this technology for sodium fluorescence has already been demonstrated in the laboratory.

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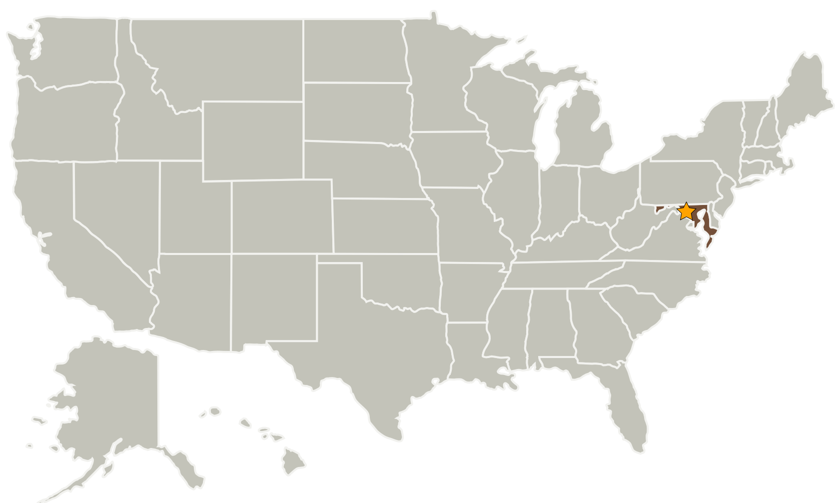
Table of Contents

Anticipated Benefits

Support NASA's strategic objectives to understand the Sun and its interactions with Earth and the solar system, including space weather. This will be achieved by developing/demonstrating instrumentation technology necessary to address the following science goals:

- Explore the physical processes in the space environment from the Sun to the Earth and throughout the solar system;
- Advance our understanding of the connections that link the Sun, the Earth, planetary space environments, and the outer reaches of our solar system;
- Develop the knowledge and capability to detect and predict extreme conditions in space to protect life and society and to safeguard human and robotic explorers beyond Earth.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Goddard Space Flight Center(GSFC)	Lead Organization	NASA Center	Greenbelt, Maryland

Primary U.S. Work Locations
Maryland

Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Lead Center / Facility:

Goddard Space Flight Center (GSFC)

Responsible Program:

Heliophysics Technology and Instrument Development for Science

Project Management

Program Director:

Roshanak Hakimzadeh

Program Manager:

Roshanak Hakimzadeh

Principal Investigator:

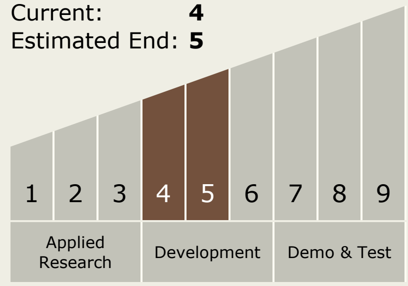
Diego Janches

Co-Investigators:

Jeffrey R Chen
Wenqian R Huang
Michael A Krainak
Oleg A Konoplev
David T Leisawitz

Technology Maturity (TRL)

Start: **4**
Current: **4**
Estimated End: **5**



Technology Areas

Primary:

- TX08 Sensors and Instruments
  - └ TX08.1 Remote Sensing Instruments/Sensors
    - └ TX08.1.5 Lasers

Target Destination

The Sun